SIMPSON ELECTRIC COMPANY

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Simpson

INSTRUMENTS

INSTRUCTION MANUAL

MODEL 2724 & 2725 ELECTRONIC COUNTER

AN ACCURATE, SOLID STATE, DIGITAL INSTRUMENT FOR TIME, FREQUENCY AND RELATED MEASUREMENTS

SIMPSON ELECTRIC COMPANY 5200 WEST KINZIE CHICAGO 60644 ILLINOIS (312) 379-1121

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PART #5—113312

FIGURE 1-1 MODEL 2724 ELECTRONIC COUNTER

FIGURE 1-2 MODEL 2725 ELECTRONIC COUNTER

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SECTION I
GENERAL INFORMATION

1-1 INTRODUCTION

1-2 The Models 2724 and 2725 are general-purpose electronic counters suitable for use in laboratory, production, servicing, and in digital systems for industrial controls. Specifically, the electronic counters are intended for any use where frequencies, periods, ratios of two frequencies, time intervals, or events are to be measured. The Model 2724 Electronic Counter has a 4-digit numerical readout display. Except for an additional readout digit, and its associated count capacity, the Model 2725 Electronic Counter is identical to the Model 2724 in both characteristics and operation. Unless otherwise specified, the information which follows applies to both electronic counters.

1-3 DESCRIPTION

1-4 The Electronic Counter provides numerical display of average frequencies from 5 Hz to 20 MHz in six ranges, period from 300 microseconds to 0.2 seconds, ratio of two frequencies, time interval, and totalizing. This highly accurate instrument features an overrange capability allowing as much as eight digit resolution in frequency measurements. Maximum reliability and a minimum number of components are achieved by utilization of monolithic integrated circuits. The instrument maintains its rated accuracy over a wide temperature range and line voltage variations. More accurate measurements can be achieved by connecting an external precision oscillator to the rear panel BNC connector which is a standard feature of the instrument. Other standard features include automatic decimal point location, variable display time, manual reset, overrange and gate time indications, high input impedance, and input overload protection. This instrument can operate with a line voltage of either 115 VAC or 230 VAC, 50-60 Hz (See Figure 2-5, Section II).

1-5 Components in the Electronic Counter have been so placed for ease of maintenance and increased instrument ruggedness. Except for the power transformer and panel controls, all circuit components are mounted on a single printed circuit board for both instrument reliability and ready access to test points. The instrument enclosure was designed for easy adaptability to a standard rack mounting configuration. Display effectiveness of the readout tubes was achieved by the utilization of a baffle and a filter to minimize reflections from both external light sources and internal tube glow. With simplified switch and control nomenclatures, operator errors are reduced to a minimum. Personnel with no experience with an instrument of this type can obtain quick and accurate measurements with minimum training.

1-6 SPECIFICATIONS

1-7 Table 1-1 lists the electrical specifications for both the Models 2724 and 2725 Electronic Counters.

TABLE 1-1 SPECIFICATIONS

FREQUENCY RANGE:	5 Hz to 20 MHz
PERIOD:	300 u sec to 0.2 sec
FREQUENCY RATIO:	a. 1 to 1.9999×10^4 — Model 2724 b. 1 to 1.99999×10^5 — Model 2725
TIME INTERVAL:	a. 300 u sec to 1.9999×10^4 sec - Model 2724 b. 300 u sec to 1.99999×10^5 sec - Model 2725
TOTALIZES FROM:	a. 0 to 1.9999×10^4 counts Model 2724 b. 0 to 1.99999×10^5 counts Model 2725
ACCURACY:	±.01% ± 1 digit over temperature range of +15°C to +55°C
TIME BASES:	0.0001, 0.001, 0.01, 0.1, 1.0, and 10 seconds
INPUT IMPEDANCE:	1 Megohm shunted by 30 pf on Channel A input 10 K ohms shunted by 30 pf on Channel B input
INPUT COUPLED:	AC (through isolation capacitor)
INPUT SENSITIVITY:	*Channel A* 0.1 V RMS minimum — 30 Hz to 20 MHz 0.5 V RMS minimum — 5 Hz to 30 Hz *Channel B* 0.1V RMS minimum — 200 Hz to 1 MHz 0.5V RMS minimum — 5 Hz to 200 Hz
DISPLAY TIME:	Variable from approximately 2 per second to hold
INPUT VOLTAGE OVERLOAD PROTECTION:	Up to 250 V RMS
POWER:	115/230 VAC ± 10% , 50-60 Hz approximately 20 watts
WEIGHT:	Approximately 8 pounds
SIZE:	4" high, 8-1/4" wide, 11" deep not including panel controls

1-8 ACCESSORIES AVAILABLE

a. Rack Mounts: Adapts instruments to a standard rack mounting configuration, 5-1/4" high and 19" wide. Provides capability of mounting one or two Electronic Counters side by side.

1-9 OPTIONS

a. Rear Input Connectors: Provide convenient input connections on rear of the unit for rack mounting configuration.

b. BCD Output: Connector on rear of the instrument provides the numerical display in a BCD 1-2-4-8 code. The levels available are:
   1. Logic "zero" — equal to or greater than + 1.4 V DC
   2. Logic "one" — equal to or less than + .35 V DC
   For connector pin identification, see Figure 1-3.

c. External Sample Command: Connector on rear of the instrument which requires a contact closure action for initiating the sampling cycle.

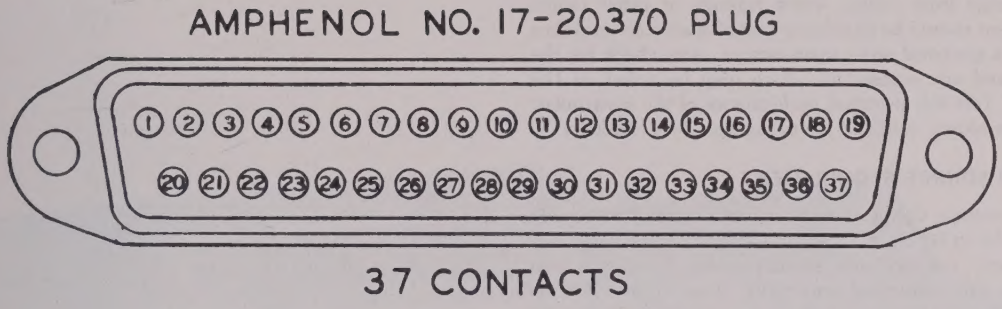


FIGURE 1-3 BCD OUTPUT CONNECTIONS

Amphenol No. 17-20370 Plug

Contact Number	BCD Output	Contact Number	BCD Output
1	A - 5	20	Sample Command
2	B -5	21	Sample Command
3	C - 5	22	Dec. 2
4	D - 5	23	Dec. 1
5	A - 3	24	D - 4
6	B - 3	25	C - 4
7	C - 3	26	B - 4
8	D - 3	27	A - 4
9	Vcc	28	GND.
10		29	Print Command
11	A - 2	30	C - 1
12	B - 2	31	A - 1
13	C - 2	32	B - 1
14	D - 2	33	D - 1
15		34	
16		35	
17		36	
18		37	
19		—	—

NOTES:

1) **For Reference See Figure 5-5 Schematic Diagram**
2) **Contacts Number 1 Through 4 Are Used Only on Model 2725.**

SECTION II
INSTALLATION

2-1 INTRODUCTION

2-2 This section contains information on unpacking, inspection, installation, and power requirement of the Electronic Counter.

2-3 UNPACKING AND INSPECTION

2-4 Examine the external covering for obvious damage. Notify the shipper if there is any sign of external damage. If not, remove the covering and examine the instrument for obvious damage from shock, water leakage or other faults. The instrument should be physically free of marks or scratches and in perfect electrical order upon receipt. Also check for the power cord and any accessories which may be noted on the packing slip. Test the electrical performance of the instrument using the procedure outlined in paragraph 5-14, Section V.

2-5 POWER SOURCE REQUIREMENT

2-6 The Electronic Counter can be operated from either a 115 or 230 volt, 50 to 60 Hz A.C. source. Special units using 400 Hz A.C. source are available upon request. Primary power requirements are connected internally (See Figure 2-5) as indicated by the rear panel label. Before plugging the Electronic Counter into the power source, check that the designation on the label matches the line voltage of your power source. The power consumption of the instrument is approximately 20 watts.

2-7 MOUNTING INSTRUCTIONS

The instrument can be set horizontally with the handle positioned along the top of the unit as shown in Figure 2-1. A convenient sloping position can be obtained by swinging the handle under the instrument and locking it in place with the handle lock as shown in Figure 2-2. The unit will operate properly in any position. However, for best viewing and convenience of operation, the sloping position is recommended. Relay rack adapters are available to mount either one or two units in a standard 5-1/4x19 inch panel area. Relay rack adapters are shown in Figures 2-3 and 2-4.

FIGURE 2-1 HORIZONTAL POSITION

FIGURE 2-2 SLOPING POSITION

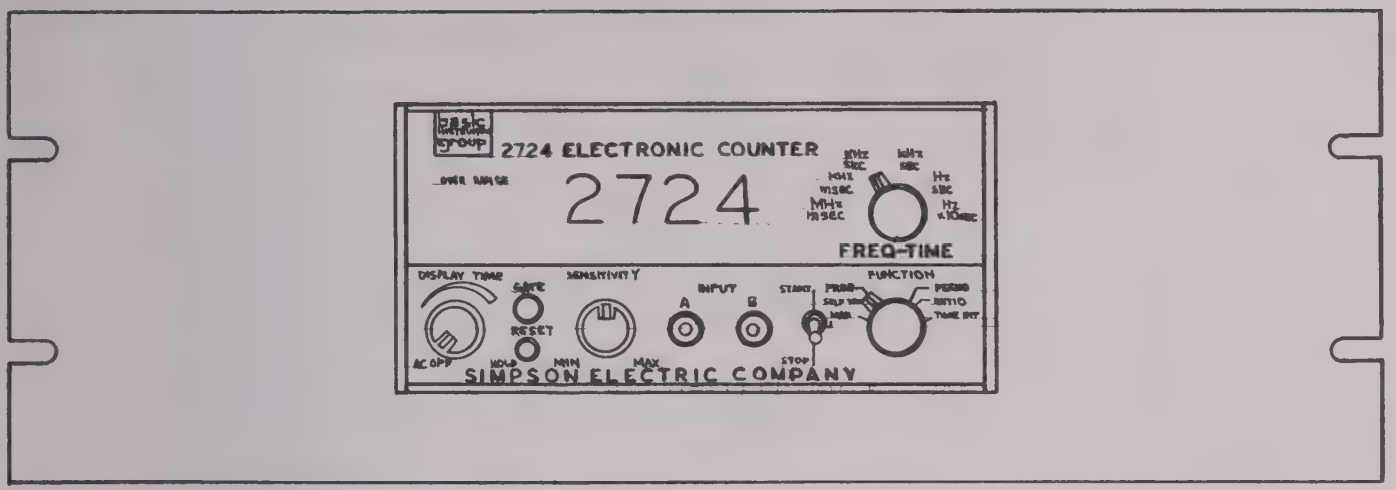


FIGURE 2-3 SINGLE RELAY RACK ADAPTER

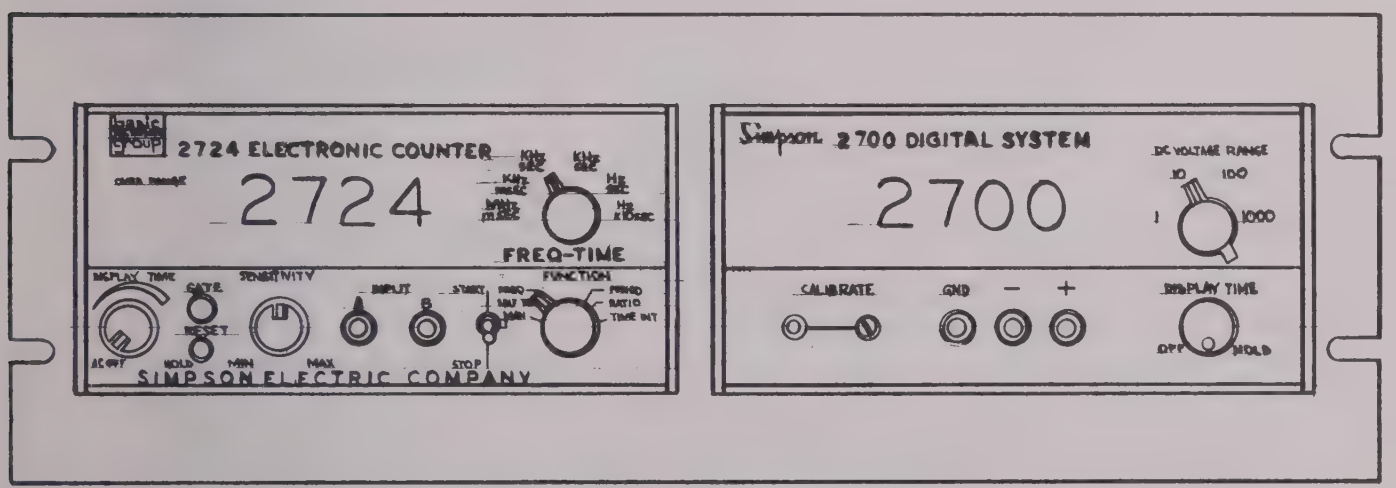
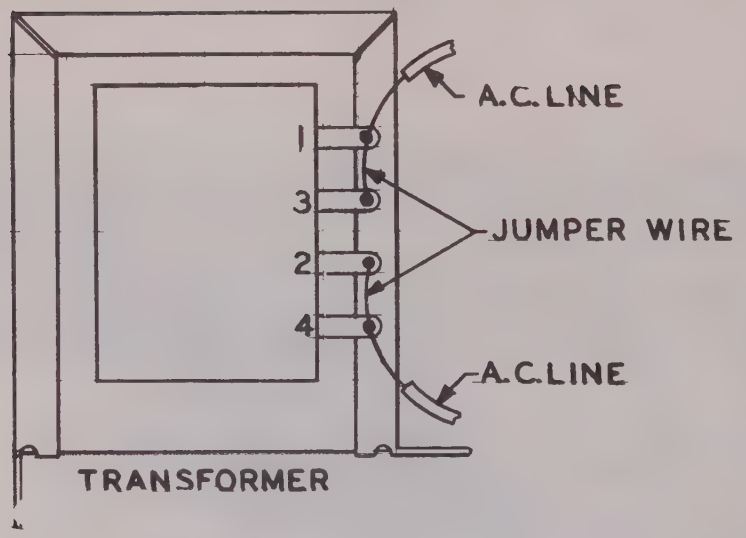
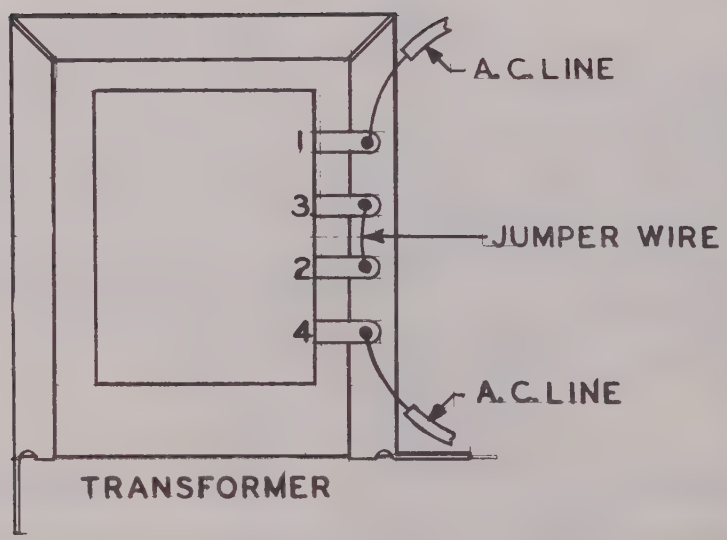


FIGURE 2-4 DUAL RELAY RACK ADAPTER



115V



230V

FIGURE 2-5 INTERNAL A.C. INPUT POWER CONNECTION

SECTION III
OPERATING INSTRUCTIONS

3-1 INTRODUCTION

3-2 The Models 2724 and 2725 Electronic Counters measure average frequency, period, ratio of two frequencies, time interval, and total events. The following provides information on control description and step by step operating procedures for each measurement function.

3-3 FRONT AND REAR PANEL DESCRIPTION

3-4 Description of front and rear panel controls and indicators is given in Figure 3-1.

3-5 OPERATING INSTRUCTIONS

3-6 FREQUENCY MEASUREMENT

3-7 Figure 3-2 outlines the operating procedure for Frequency Measurement.

3-8 PERIOD MEASUREMENT

3-9 Figure 3-3 outlines the operating procedure for Period Measurement.

3-10 RATIO MEASUREMENT

Figure 3-4 outlines the operating procedure for Ratio Measurement.

3-11 TIME INTERVAL MEASUREMENT

Figure 3-5 outlines the operating procedure for Time Interval Measurement.

3-12 MANUAL (TOTALIZING)

Figure 3-6 outlines the operating procedure for totalizing event.

3-13 SELF TEST

Figure 3-7 describes the operating procedure for self-checking instrument.

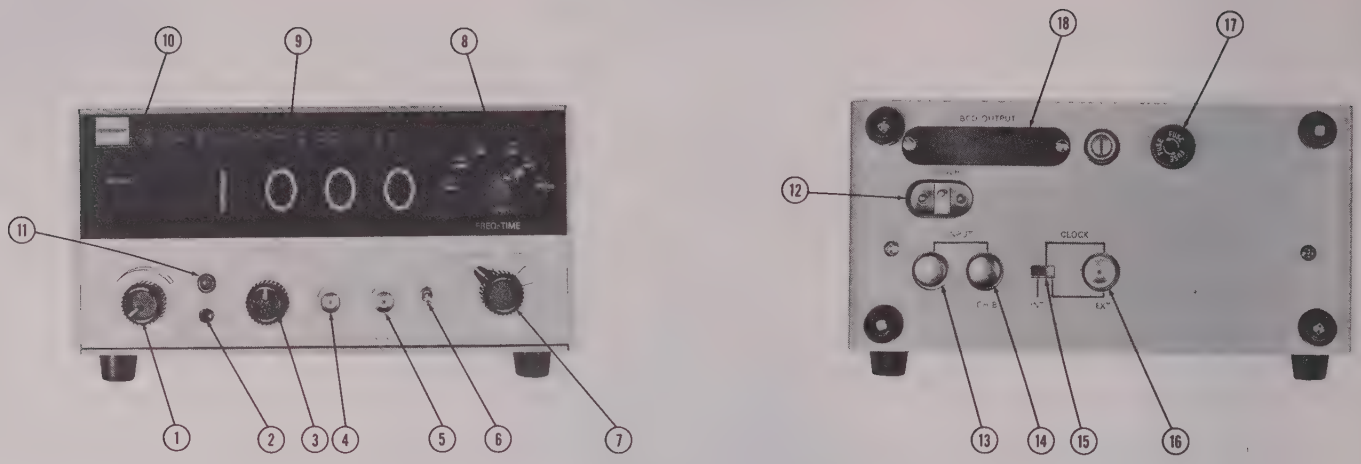


FIGURE 3-1 FRONT AND REAR PANEL

1. DISPLAY TIME/AC OFF control applies primary power to the instrument and varies the display time rate from 1/2 second to hold position.
2. RESET push-button switch returns both displayed and internal count to zero and initiates the sampling cycle when pressed.
3. SENSITIVITY control attenuates the input signal for proper operation. As signals approach higher levels, the control should approach the min. position.
4. CHANNEL A input connector provides A.C. coupling to main amplifier for most measurements.
5. CHANNEL B input connector provides A.C. coupling to secondary amplifier for Ratio and Time Interval measurements.
6. START-STOP switch provides control when the FUNCTION switch is in the MANUAL position for totalizing measurements.
7. FUNCTION switch:
   a. MANUAL permits counting of events applied to INPUT A. By using the START-STOP switch, control of the desired counting interval of events or pulses is obtained.
      The RESET push button must be pressed to start this function.
   b. SELF TEST permits checking of the internal logic circuitry operation with an internal frequency of 10 K Hz. The position of the decimal point displayed is selected by the FREQ-TIME switch.
   c. FREQ permits measurement of average frequency applied to INPUT A during a time interval selected by FREQ-TIME switch.
   d. PERIOD permits cycle duration measurement of signal applied to INPUT A within time range selected by FREQ-TIME switch.
   e. RATIO permits measurement of the ratio between the frequency applied to INPUT A and the frequency applied to INPUT B. The lower frequency signal must be applied to INPUT B.
   f. TIME INT permits measurement of time between a pulse applied first to INPUT A and a pulse applied to INPUT B with the time base selected by FREQ-TIME switch. Both pulses are triggered on the negative going edges.
8. FREQ-TIME switch selects either time that gate is on for frequency measurement or time unit per count for period and time interval measurements.
9. READOUT DISPLAY indicates magnitude of the measured signal using numerical neon glow tubes.
10. OVERRANGE indicator illuminates when the measured signal value has exceeded the full scale range.
11. GATE indicator illuminates when the gate is open during a measurement cycle.
12. A.C. POWER connects to the primary power cable supplied with the instrument.
13. INPUT A connector on rear panel provides A.C. coupling to main amplifier.

    It is available as an option only.
14. INPUT B connector on rear panel provides A.C. coupling to secondary amplifier.

    It is available as an option only.
15. INTERNAL-EXTERNAL clock selector enables the instrument to operate from either the internal oscillator (100 KHz) or an external clock source connected to the BNC connector provided. The external clock signal must contain rise and fall times of less than 100 nanoseconds and levels of 0 ± 0.4V and 3.6 ± 0.4V.
16. EXTERNAL CLOCK connector provides connection to an external oscillator.
17. FUSE — 1/2A slow-blow type, size 3AG.
18. BCD output connector provides the binary-coded-decimal outputs of all-decade counters and print command signal. This connector is available as an option.

FIGURE 3-2 FREQUENCY MEASUREMENT

1. Turn DISPLAY TIME control clockwise from AC OFF position to turn instrument on.
2. Set FUNCTION switch to FREQ position.
3. Set FREQ-TIME switch for desired count (gate) time or time base.
4. Set CLOCK switch (REAR PANEL) to INT position.
5. Connect unknown signal to INPUT A connector.
6. Adjust SENSITIVITY control until a consistent reading is obtained.
7. Read frequency from display. Decimal point is correctly positioned and correct measurement unit in Hz, KHz or MHz is indicated by the FREQ-TIME switch position.

CAUTION
Do not apply more than 250 Volts RMS to input.

FIGURE 3 3 PERIOD MEASUREMENT

1. Turn DISPLAY TIME control clockwise from A.C. OFF position to turn instrument on.
2. Set FUNCTION switch to PERIOD position.
3. Set FREQ-TIME switch for desired count (gate) time.
4. Set CLOCK switch (REAR PANEL) to INT position.
5. Connect unknown signal to INPUT A connector.
6. Adjust SENSITIVITY control until a consistent reading is obtained.
7. Read time of period from display. Decimal point is correctly positioned and correct unit in m sec or sec is indicated by the FREQ-TIME switch position.

CAUTION
Do not apply more than 250 Volts RMS to input.

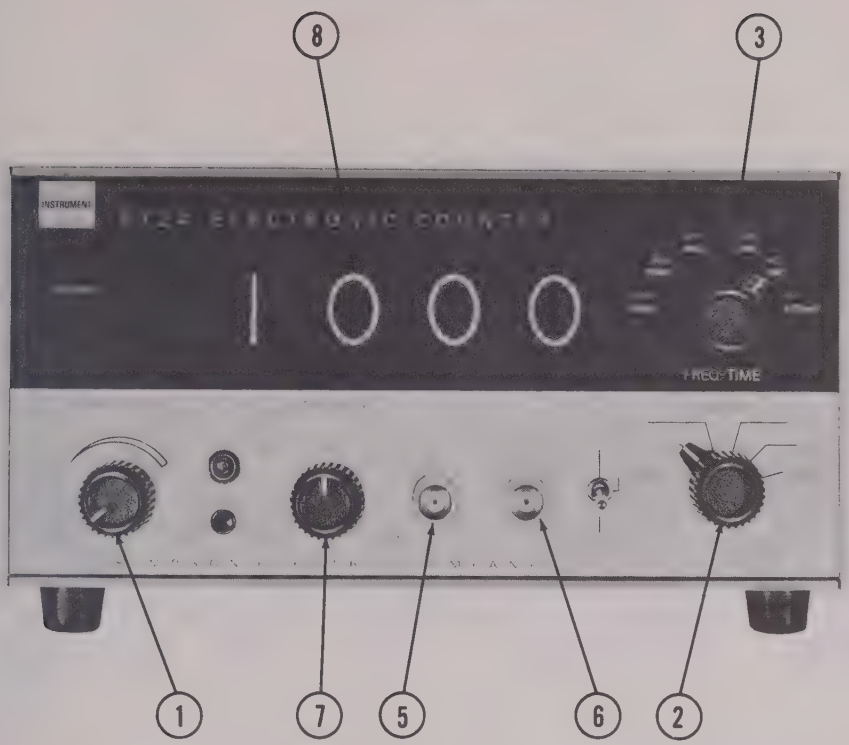


FIGURE 3-4 RATIO MEASUREMENT

1. Turn DISPLAY TIME control clockwise from AC OFF position to turn instrument on.
2. Set FUNCTION switch to RATIO position.
3. Connect the higher frequency signal to INPUT A connector.
4. Connect the lower frequency signal to INPUT B connector.
5. Adjust SENSITIVITY control switch until a consistent reading is obtained.
6. Read the ratio A/B of the two frequencies from display. Decimal point is correctly positioned.

NOTE:
FREQ-TIME switch is inoperative in this function.

CAUTION
Do not apply more than 250 Volts RMS to inputs.

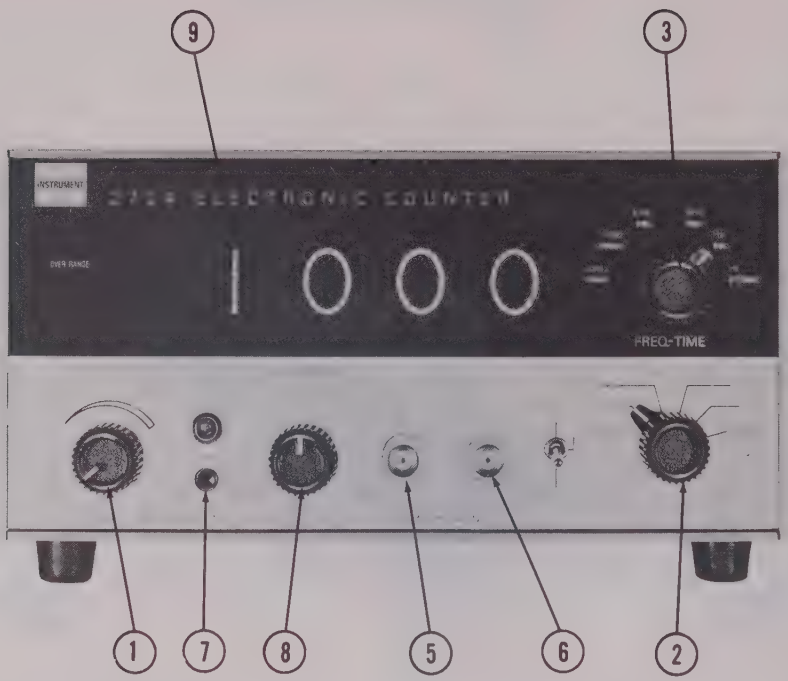


FIGURE 3-5 TIME INTERVAL MEASUREMENT

1. Turn DISPLAY TIME control clockwise from AC OFF position to turn instrument on. Set control to extreme right for Hold Position.
2. Set FUNCTION switch to TIME INT position.
3. Set CLOCK switch (on rear panel) to INTernal position.
4. Set FREQ-TIME switch for desired time base. In the furthest clockwise position the readout will indicate time in ten second intervals. In the extreme counterclockwise position time will be indicated in millisecond intervals with resolution to tenths of a millisecond. Intermediate time bases will be found on the four intermediate positions of the FREQ-TIME switch.
5. Connect start-pulse signal source to INPUT A. Do not yet provide signal.
6. Connect stop pulse signal source to INPUT B.
7. Momentarily depress RESET push-button switch.
8. Initiate start-pulse signal and continue to reapply signal (it must be a pulse, not continuously applied DC) while rotating SENSITIVITY control until GATE light goes on, indicating that the time counting circuits have started.
9. Read time interval from display. Decimal point is correctly positioned and correct unit in m sec or sec is indicated by the FREQ-TIME switch position.
10. Unit will continue to count until stop pulse is applied to INPUT B or RESET button is again depressed.

CAUTION

Do not apply more than 250 Volts RMS to input.

FIGURE 3-6 MANUAL (TOTALIZING)

1. Turn DISPLAY TIME control clockwise from AC OFF position to turn instrument on. Set control to extreme right for HOLD position.
2. Set FUNCTION switch to MANUAL position.
3. Set START-STOP switch to STOP position.
4. Connect event or pulse source to INPUT A connector.
5. Momentarily depress RESET push-button switch.
6. Start counting by turning the START-STOP switch to START position.
7. Stop the count by turning the START-STOP switch to STOP position.
8. If no reading is obtained, or if the readings obtained are erratic, adjust the SENSITIVITY control and repeat steps 5, 6, and 7.
9. Read number of input pulses or events from display.

CAUTION

Do not apply more than 250 Volts RMS to input.

FIGURE 3-7 SELF TEST

1. Turn DISPLAY TIME control clockwise from AC OFF position to turn instrument on.
2. Set FUNCTION switch to SELF TEST position.
3. Set CLOCK switch to internal position.
4. Set FREQ-TIME switch for desired count (gate) time or time base.
5. Read 10 KHz frequency from display. Decimal point is correctly positioned and correct measurement unit in Hz, KHz, or MHz is indicated by the FREQ-TIME switch position. Table below indicates correct displays with different time bases.

FREQ-TIME Position	*MODEL 2724*		*MODEL 2725*	
	Display	*Overrange*	*Display*	*Overrange*
1st Pos. MHz — m sec	00.01	Off	000.01	Off
2nd Pos. KHz — m sec	0010	Off	00010	Off
3rd Pos. KHz — sec	010.0	Off	0010.0	Off
4th Pos. KHz — sec	10.00	Off	010.00	Off
5th Pos. Hz — sec	0000	On	10000	Off
6th Pos. Hz — X10 sec	000.0	On	0000.0	On

SECTION IV
THEORY OF OPERATION

4-1 INTRODUCTION

4-2 This section describes the operation of the Model 2724 Electronic Counter. The operation of the Model 2725 Electronic Counter is identical except for an additional readout assembly. All modes of operation are described first. Then the description of circuits follows. Figure 4-1 shows the overall block diagram of the instrument.

4-3 GENERAL

4-4 The basic counter circuits are arranged to provide several functional modes of operation. Each mode includes an "AND" gate with two inputs — the signal input and a control input, or gating signal. Following the "AND", gate is a cascaded series of decade counters which accumulate and display the total number of pulses which passed through the gate. Circuit sequence in the various modes of operation is similar: pulses pass through the "AND" gate to the decimal counters for a predetermined time, are counted and displayed. The difference between modes is in 1) the source of the pulses counted, and 2) the source of the gating signal which establishes the length of time during which the gate is open to pass pulses to the decimal counters.

4-5 FREQUENCY MEASUREMENT

4-6 As shown in Figure 4-2A, the circuit arrangement permits control of the gate by the decade dividers which represent the time base. The gate is opened for a controlled time; therefore, the accumulated count represents the number of input cycles or pulses during this time. Controlled intervals are from 10 seconds down to 100 microseconds in decade sub-multiples, selectable with the front panel FREQ-TIME switch. The decimal point is automatically positioned and the readout is in Hz, KHz and MHz as indicated by the switch position.

4-7 PERIOD MEASUREMENT

4-8 The arrangement shown in Figure 4-2B provides the means for measuring the period of the input signal. The period of a signal is the time required for the completion of one cycle; the counter displays the time in seconds or milliseconds. The period measurement is obtained by making the duration of the gating signal equal to the period of the input signal, and counting a train of pulses supplied by the decade dividers. The displayed count is the number of time-base pulses which occur during one period of the input signal. The decimal point is automatically positioned by the setting of the FREQ-TIME switch to indicate seconds or milliseconds.

4-9 RATIO MEASUREMENT

4-10 As shown in Figure 4-2C, the frequency ratio of two inputs can be measured by a circuit arrangement similar to that used for period measurement. One input signal is applied to the gate while the gating signal is made equal to the period (or decade multiple of the period) of the other signal. The displayed count represents the number of cycles of one input which occur during the period of one cycle (or decade multiple of one cycle) of the other input.

4-11 TIME INTERVAL MEASUREMENT

4-12 As shown in Figure 4-2D, the circuit arrangement for the Time Interval Measurement is similar to that used for the Period Measurement. The signal from the decade dividers serves as the input pulses to the gate and the signals from the two inputs control the gate. The input pulse from Channel A opens the gate and the input pulse from Channel B closes the gate. The displayed count represents the number of cycles counted as time between the occurrence of the two input pulses. The decimal point is automatically positioned and the readout is in seconds or milliseconds as indicated by the FREQ-TIME switch position.

4-13 MANUAL (TOTALIZING)

4-14 In the Manual mode of operation (Figure 4-2E) the gate is controlled by the FUNCTION switch when it is in the MANUAL START or MANUAL STOP position. The gate closes when the switch is in the MANUAL STOP position and the number of pulses which came through the gate are displayed.

4-15 AMPLIFIER A

4-16 Amplifier A is an AC coupled amplifier which uses the common-emitter transistor configuration. High input impedance is achieved by using a Junction Field Effect Transistor as the input stage. Through frequency compensating networks, sufficient gain is maintained for frequencies between 5 Hz and 20 MHz. Input overload protection is provided by the use of two silicon diodes at the input of the amplifier. Amplifier B is a single stage transistor AC amplifier which is used to amplify the Channel B input signal.

4-17 SCHMITT TRIGGER A

4-18 The Schmitt Trigger Circuit consists of two transistors followed by a transistor inverter which serves as a level converter. The circuit, which triggers on positive going signals from the amplifier, produces one pulse for each cycle of the input signal. The pulse width depends on the amplitude of the input signal and setting of the SENSITIVITY control. Schmitt Trigger B, identical in construction to Schmitt Trigger A, is used for Channel B.

4-19 OSCILLATOR, 100 KHz

4-20 The 100 KHz Oscillator is a crystal controlled oscillator using Resistor-Transistor-Logic gates as amplifiers. The output frequency of the oscillator circuit can be adjusted if required over a narrow range by the adjustment of a trimmer capacitor.

4-21 DECADE DIVIDERS

4-22 Each of the six Decade Dividers consists of J-K Flip-Flops connected in a divide by-ten, binary counter configuration. The output of each decade divider is a square wave signal whose frequency is a sub-multiple of the 100 KHz Oscillator frequency in decades. The six frequency sources available are: 10 KHz, 1 KHz, 100 Hz, 10 Hz, 1 Hz and 0.1 Hz. These frequency sources serve as time bases to the instrument. All J-K Flip-Flops used are of the monolithic Resistor-Transistor Logic integrated circuit family.

4-23 GATING CIRCUIT

4-24 The Gating Circuit consists of an "AND" gate and the Gate Control Multivibrator. The "AND" gate is a 2-input integrated circuit gate whose function is to control the number of pulses fed into the Decade Counters. In frequency measurement, the signal appears at one input, and the time-base signal, which acts as the controlling element, appears at the other input. The two sources to the input of the gate are reversed in period measurement. The Gate Control Multivibrator performs the function of enabling and inhibiting the "AND" gate. The Gate Control Multivibrator is initiated by the Reset Circuit. The first positive-going edge of the signal triggers the flip-flop to the open state and the second positive going edge, which occurs at the end of one complete cycle, triggers the flip-flop to its closed state. This process is repeated with the presence of another pulse from the Reset Circuit. In the MANUAL function, the gate is controlled by the front panel START-STOP switch.

4-25 DISPLAY TIME GENERATOR

4-26 The Display Generator is a unijunction transistor relaxation oscillator. The output frequency of the generator, adjusted with the front panel DISPLAY TIME control, determines the sampling rate of the unit.

4-27 RESET CIRCUIT

4-28 The Reset Circuit consists of a monostable multivibrator and buffer to drive the Decade Counters into reset states. It also initiates the control pulse to the gating circuits. Output of the unijunction oscillator and the signal from the front panel RESET switch are connected as inputs to the monostable multivibrator.

4-29 DECADE COUNTERS

4-30 The monolithic integrated circuit Decade Counters totalize the pulses derived from the input signal to provide a digital representation of the number of pulses. Each decade counter consists of four flip-flops. A combination of output levels from the flip-flops represent one of ten decimal digits when the binary coded decimal (BCD) weight 1, 2, 4, or 8 is assigned to the ONE state of each flip-flop. For example, if flip-flops A. B. C. and D are weighted 1, 2, 4, and 8 respectively, and if A and D are in the zero state and B and C are in the one state, the decimal digit represented is $0 + 2 + 4 + 0 = 6$. A decimal digit greater than 9 is not possible because of the internal connections of the four flip-flops.

4-31 DECODER/DRIVER

4-32 As the name implies, the monolithic integrated circuit Decoder/Driver performs two functions: to convert the outputs of the Decade Counters from a binary number to a decimal number and to serve as high voltage drivers for the readout tubes. Four lines of the BCD 1, 2, 4, 8 are connected as inputs to the Decoder/Driver and ten lines are connected to the ten cathodes of the readout tube as outputs which represent the ten decimal numbers for display. The number to be displayed in the readout tube is determined by the low level output at one of the ten outputs of the Decoder/Driver.

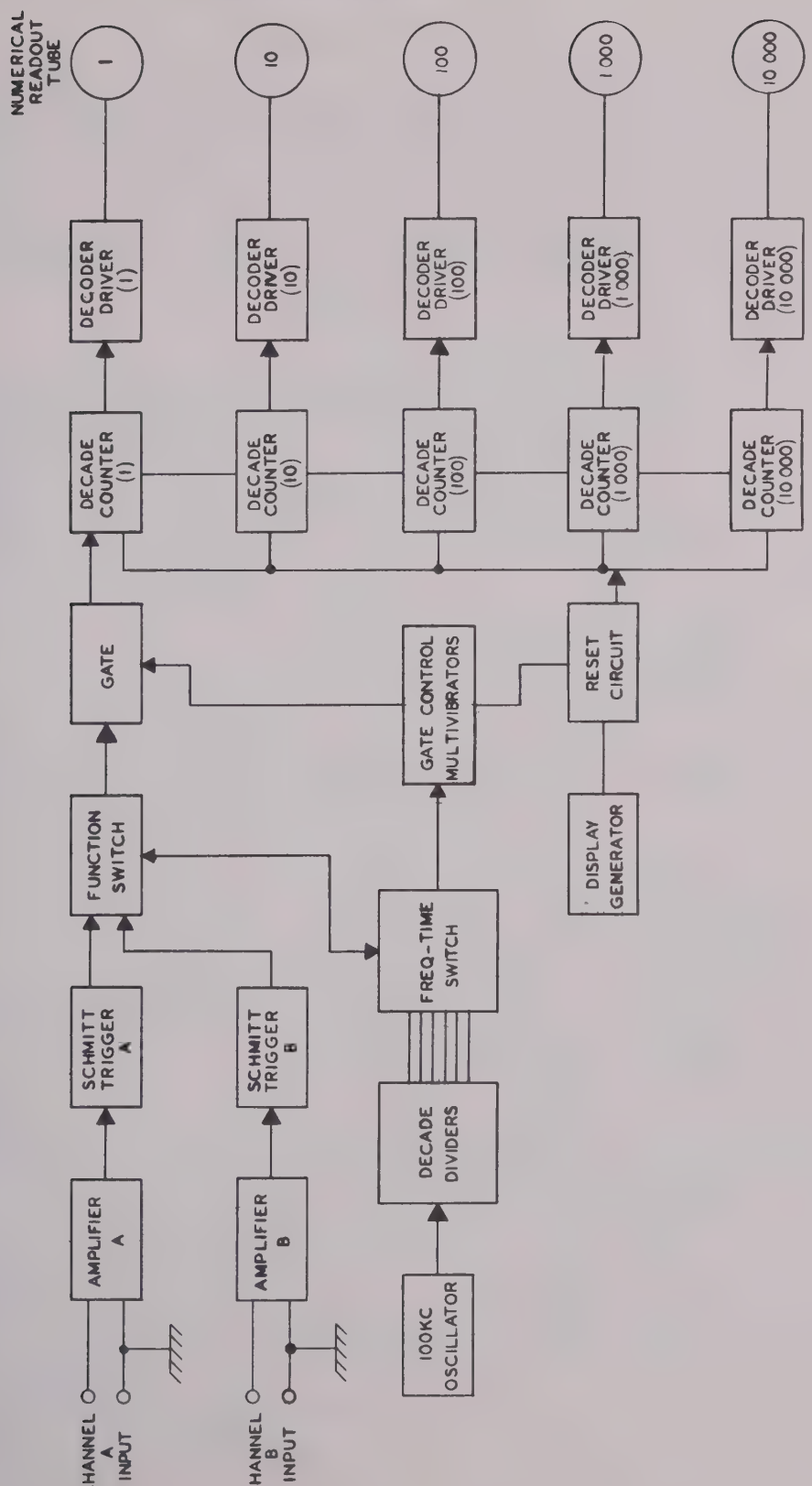


FIGURE 4-1 BLOCK DIAGRAM

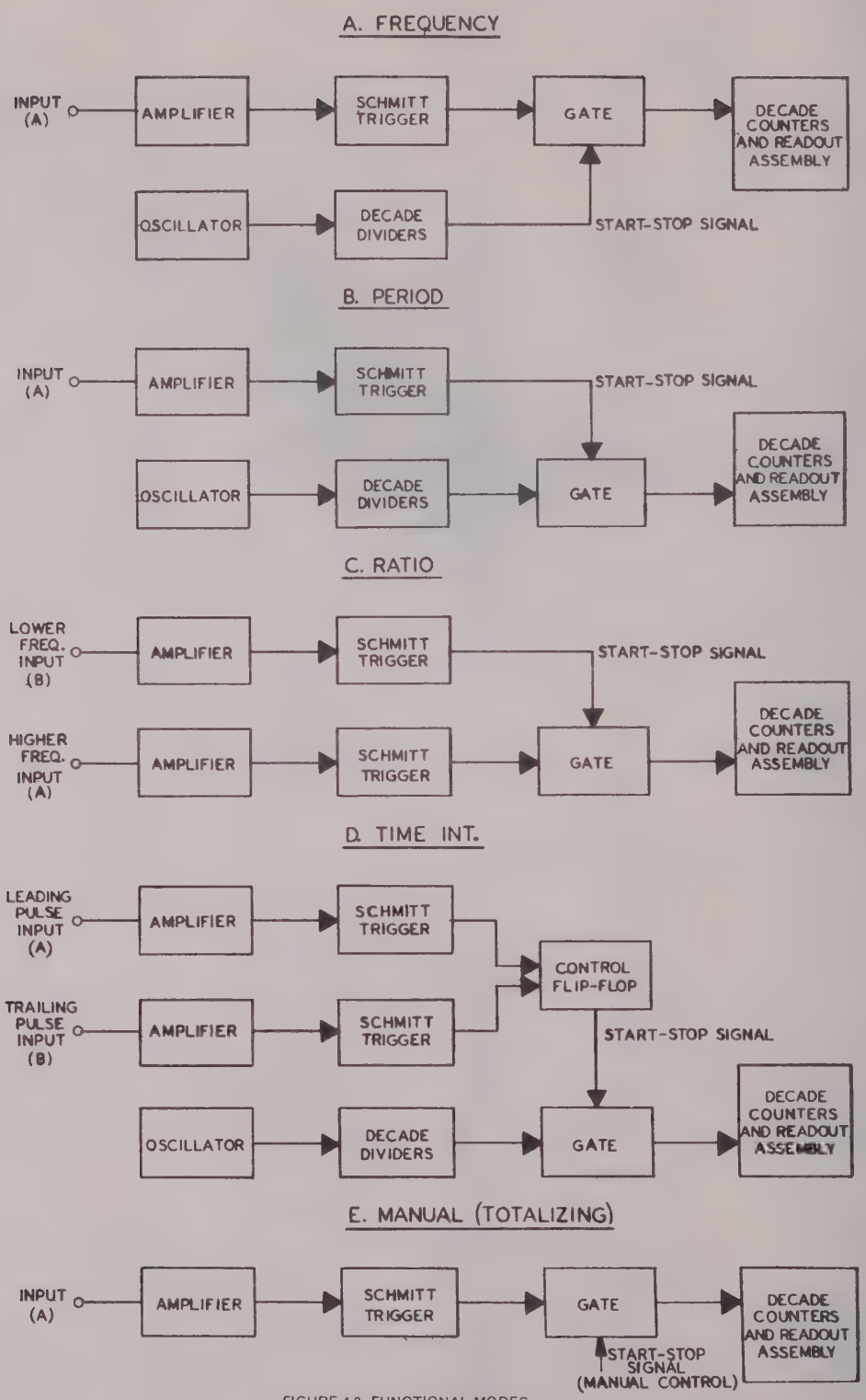


FIGURE 4-2 FUNCTIONAL MODES

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section provides maintenance, calibration procedure, performance check and trouble-shooting procedure of the instrument. The procedures provided may be used

a. as part of an incoming inspection check of instrument specifications.
b. after any repairs or adjustments, before returning instrument to regular service.
c. periodically, for instruments used in systems where maximum reliability is of utmost importance.
d. as part of a trouble-shooting procedure to locate malfunctioning circuits.

5-3 LINE VOLTAGE

5-4 During the Performance Check, the instrument should be connected to power source through a variable voltage device so that line voltage may be varied ± 10% from 115 or 230 VAC to assure satisfactory performance under various supply conditions.

5-5 REQUIRED TEST EQUIPMENT

5-6 Table 5-1 lists recommended test equipment required for maintenance and calibration of the instrument. Test equipment other than that listed may be used if their specifications equal or exceed the required characteristics.

5-7 INSTRUMENT COVER REMOVAL

5-8 To remove the top cover, turn the fastener (located on the rear of the instrument) 1/4 turn counterclockwise. Slide the cover approximately 1/2 inch forward and lift upward. This procedure should be reversed to replace the cover.

5-9 To remove the bottom cover, first remove the four rubber feet and then lift the cover off the instrument. Note the position of the handle lock and spring washer. These parts should be assembled in reverse order to replace the cover.

5-10 PRINTED CIRCUIT COMPONENT REPLACEMENT

5-11 Component lead holes in the circuit board have plated walls to ensure good electrical contact between conductors on the opposite sides of the board. To prevent damage to this plating and to the replacement component, apply heat sparingly and work carefully. The following replacement procedure is recommended.

a. Remove defective component.
b. Melt solder in component lead holes. Use clean dry soldering iron to remove excess solder. Clean holes with toothpick or wooden splinter. Do not use metal tool for cleaning as this may damage through-hole plating.
c. Bend lead of replacement component to the correct shape and insert component leads into component lead holes. Using heat and solder sparingly, solder leads in place. Heat may be applied to either side of board. A heat sink (longnose pliers, commercial heat-sink tweezers, etc.) should be used when replacing semi-conductors in order to prevent conduction of excessive heat from the soldering iron to the component.
d. Through-hole plating breaks are indicated by the separation from the board of the round conductor pad on either side of the board. To repair breaks, press conductor pads against board and solder replacement component lead to conductor pad on both sides of the board.

5-12 CALIBRATION

5-13 Table 5-2 outlines the Calibration procedure.

5-14 PERFORMANCE CHECK

5-15 The following performance check is used to verify the specifications of the instrument. It should be performed after completion of the Calibration test as shown in Table 5-2.

5-16 FREQUENCY MEASUREMENT CHECK

5-17 Table 5-3 outlines the Frequency Measurement Check procedure.

5-18 PERIOD MEASUREMENT CHECK

5-19 Table 5-4 outlines the Period Measurement Check procedure.

5-20 RATIO MEASUREMENT CHECK

5-21 Table 5-5 outlines the Ratio Measurement Check procedure.

5-22 TIME INTERVAL MEASUREMENT CHECK

5-23 Table 5-6 outlines the Time Interval Measurement Check procedure.

5-24 TOTALIZING MEASUREMENT CHECK

5-25 Table 5-7 outlines the Totalizing Measurement Check procedure.

5-26 FOR SELF TEST procedure, see Paragraph 3-13, Section III.

5-27 TROUBLE-SHOOTING

5-28 Trouble-Shooting aids

a. Principles of Operation — Section IV.
b. Schematic Wiring Diagram — Section V.
c. Block Diagram — Figure 4-1, Section IV.
d. Trouble-Shooting Chart — Table 5-8, Section V.
e. Typical Waveforms — Figure 5-3, Section V.
f. Timing Diagram — Figure 5-2, Section V.
g. Typical Power Supply Voltages — Table 5-9, Section V.
h. Localizing Diagram (SELF TEST MODE) — Figure 5-4, Section V.

5-29 TROUBLE-SHOOTING CHART

5-30 Table 5-8 outlines the various common malfunctions and probable causes during operation of the instrument as a guide in trouble-shooting. During any stage in the process of debugging, one should always inspect the instrument for loose, burned, or broken components, loose connections, and broken leads which would be a source of trouble.

5-31 LOCALIZING DIAGRAM (SELF TEST MODE)

5-32 Figure 5-4 outlines the procedure for localizing the malfunction when the instrument is operated in the SELF TEST mode.

TABLE 5-1 RECOMMENDED TEST EQUIPMENT

Instrument Type	*Required Characteristics*	*Model Recommended*
Frequency Counter	Frequency range: 0 to 25 MHz Period range: 500 us to 200 ms Sensitivity: 0-1 V RMS Minimum Accuracy: 1 part in 10^5	HP Model 5245L
Bridge Oscillator	Frequency range: 500 KHz to 25 MHz Output level: 0 to 1 V RMS across 50 ohm load Freq.-Accuracy: ±10%	General Radio Type 1330A
Wide-Range Oscillator	Frequency range: 5 Hz to 600 KHz Output level: 0 to 10 V RMS across 600 ohm load Freq.-Accuracy: ±10%	HP Model 200CD
Oscilloscope	50 MHz band width, dual trace plug-in, external sync capability	Tektronix 545B with Type 1A1 Dual Trace plug-in

TABLE 5-2 CALIBRATION

1. Allow instrument to warm up for 1 hour with top cover in place.
2. Set instrument controls as follows:
   CLOCK switch to INT position (rear panel).
   FREQ TIME to Hz - X10 sec position.
   FUNCTION switch to SELF TEST position.
3. Set HP5245L to read 100.000 KHz in the Frequency mode with 1 Sec time base.
4. Remove top cover from instrument.
5. Connect Test Point A (See Figure 5-1) and convenient ground to AC SIGNAL INPUT of the HP5245L.
6. Adjust trimmer with a non-metalic tool (Figure 5-1) on printed circuit board to obtain a reading of 100.000 KHz, ± .001 Hz from HP5245L display.
7. Remove test lead and replace top cover.

TABLE 5-3 FREQUENCY MEASUREMENT CHECK

A. High Frequency

1. Set instrument controls as follows:
   CLOCK switch to INT position.
   DISPLAY TIME slightly clockwise out of AC OFF position.
   FUNCTION to FREQ position.
   FREQ-TIME to MHz - m sec position.
   SENSITIVITY to MAX position.
2. Connect output of 1330-A Bridge Oscillator to A input of instrument, AC input of HP5245L and TEKTRONIX 545B oscilloscope.
3. Adjust Bridge Oscillator for a signal of 20000.000 KHz ± 1.000 KHz as read on 5245L counter and a level of 0.28 V PP on oscilloscope.
4. The reading indicated on Model 2724 or 2725 should be between 19.98 and 20.02 MHz.
5. Vary the FREQ-TIME switch positions. The following readings should be displayed:

FREQ-TIME Position	*MODEL 2724 Count Observed Between*	*MODEL 2725 Count Observed Between*
Hz - sec	*7999 - 2001	*97999 - 02001
KHz - sec	*9799 - 02.01	*99799 - 002.01
KHz - sec	*9979 - 0002.1	*99979 - 0002.1
KHz - M sec	*9996 - 0003	19996 - 20003
MHz - M sec	19.98 - 20.02	019.98 - 020.02

* indicates overrange indicator ON

B. Low Frequency

1. Set instrument controls as follows:
   CLOCK switch to INT position.
   DISPLAY TIME slightly clockwise out of AC OFF position.
   FUNCTION to FREQ position.
   FREQ-TIME to Hz - sec position.
   SENSITIVITY to MAX position.
2. Connect output of HP 200 CD Wide Range Oscillator to A input of instrument, DC input of HP5245L, and TEKTRONIX 545B oscilloscope.
3. Adjust HP 200 CD Oscillator for a signal of 10 Hz as read on HP5245L counter and a level of not less than 1.0 V PP on oscilloscope.
4. The readout of the Model 2724 or 2725 should be 10 ± 1 Hz. (Adjust SENSITIVITY control if desired result is not obtained).
5. Repeat steps 1 through 4 for frequencies of 20, 30, 100, and 1000 Hz from the oscillator with an amplitude of less than 0.28 V PP. The readout accuracy should be .01% of reading ± 1 digit using the HP5245L as a standard.

TABLE 5-4 PERIOD MEASUREMENT CHECK

1. Set instrument controls as follows:
   CLOCK switch to INT position.
   DISPLAY TIME slightly clockwise out of AC OFF position.
   FUNCTION to PERIOD position.
   FREQ-TIME to MHz - m sec position.
   SENSITIVITY to MAX position.
2. Connect output of HP 200 CD Wide Range Oscillator to A input of instrument, DC input of HP5245L, and TEKTRONIX 545B oscilloscope.
3. Adjust oscillator for a reading of 100,000.0 μs $\pm$ 50 μs as indicated on HP5245L and a level of not less than 0.28 V PP on oscilloscope.
4. The readout of the Model 2724 or 2725 should be 100.0 m sec $\pm$ 1 digit.
5. Turn FREQ-TIME switch to KHz - m sec position. The readout should be 100 m sec $\pm$ 1 digit.
6. Turn FREQ-TIME switch to left hand KHz - sec position. The readout should be 000.1 sec $\pm$ 1 digit.

TABLE 5-5 RATIO MEASUREMENT CHECK

1. Set instrument controls as follows:
   DISPLAY TIME slightly clockwise out of AC OFF position.
   FUNCTION to RATIO position.
   SENSITIVITY to MAX position.
2. Connect HP 200 CD Wide Range Oscillator output to HP5245L counter and oscilloscope.
3. Adjust oscillator to a reading between 199,990.0 u sec and 200,010.0 u sec with amplitude of 3.0 V P-P.
4. Disconnect oscillator output from HP5245L counter and oscilloscope; connect to B input of Model 2724 or 2725.
5. Connect General Radio 1330A Bridge Oscillator output to HP5245L counter, TEKTRONIX 545B oscilloscope, and A input of Model 2724 or 2725.
6. Adjust Bridge Oscillator for a reading between 99.990 KHz and 100.010 KHz on HP5245L counter with amplitude of 0.28 V PP on oscilloscope.
7. Observe following reading on instrument.
   a. MODEL 2724 — observed count should be between 9997 and 0003 with the OVERRANGE indicator on.
   b. MODEL 2725 — observed count should be between 19997 and 20003.

TABLE 5-6 TIME INTERVAL MEASUREMENT CHECK

1. Set instrument controls as follows:
   CLOCK switch to INT position.
   DISPLAY TIME to HOLD position.
   FUNCTION to TIME INT position.
   FREQ-TIME to Hz - sec position.
   SENSITIVITY to MAX position.
2. Adjust HP 200 CD Wide Range Oscillator for 100 Hz with AMPLITUDE control to MID-scale position, nominally 5 volts RMS output.
3. Momentarily depress RESET pushbutton switch on instrument. Count should be 0000 on MODEL 2724 or 00000 on MODEL 2725.
4. Momentarily connect output of oscillator to A input. Instrument starts counting at a rate of one per second.
5. Momentarily connect output of oscillator to B input. Instrument stops counting.
6. The number indicated on readout in seconds indicates the time interval between the occurrances of the signal at the two inputs.

TABLE 5-7 TOTALIZING MEASUREMENT CHECK

1. Set instrument controls as follows:
   DISPLAY TIME to HOLD position.
   FUNCTION to MANUAL position.
   SENSITIVITY to MIDDLE position.
   START-STOP to STOP position.
2. Connect output HP of 200 CD Wide Range Oscillator to A input of instrument.
3. Set controls on oscillator for 10 Hz signal.
4. Momentarily depress RESET pushbutton switch. Readout should be 0000 on MODEL 2724 or 00000 on MODEL 2725.
5. Set START-STOP switch to START position.
6. Adjust AMPLITUDE control of oscillator until the instrument starts counting. The rate of counting as shown on the second least significant digit should be approximately one per second.
7. Set START-STOP switch to STOP position. The counting stops. The readout indicated represents the number of cycles or pulses which have entered the counter within the START to STOP period. (The counting continues to accumulate with the switch in the START position.)

TABLE 5-8 TROUBLE-SHOOTING CHART

MALFUNCTION	PROBABLE CAUSE OF FAILURE
1. Display not lit.	a. Instrument not plugged in. b. Line fuse (1/2 A). c. Line switch. d. Power transformer connection. e. +200 V supply.
2. No counting in SELF TEST mode of operation.	a. Clock switch on rear panel. b. Control gate X-1. c. Control flip-flops X-26. d. 100 KHz oscillator. e. Decade dividers. f. Decade counters. g. Decoder/Drivers. h. Function switch.
3. Erroneous readout in SELF TEST mode of operation.	a. Control flip-flops X 26. b. Decade dividers. c. Decoder/Drivers. d. Decade counters. e. Excessive ripple content on supply voltages. (See Table 5-9, Section V).
4. Instrument operates in SELF TEST mode, but does not function in FREQUENCY and PERIOD measurements.	a. Input connection. b. SENSITIVITY control. c. Channel A Amplifier and Schmitt Trigger. d. Flip-flop X-25. e. FUNCTION switch. f. FREQ-TIME switch. g. 6 V supply.
5. Instrument operates in FREQUENCY and PERIOD modes, but does not operate in RATIO mode.	a. Channel B input connector. b. Channel B. Amplifier and Schmitt Trigger. c. Gates X-1. d. FUNCTION switch.
6. Malfunctions in TIME INTERVAL mode, but operates in all other modes.	a. Flip-flop X-25. b. Gates X-1. c. Diodes D-4 and D-5. d. FUNCTION switch. e. FREQ-TIME switch.
7. Instrument does not sample.	a. Unijunction oscillator. b. Reset circuit. c. Control flip-flops X-26. d. Gates X-1. e. FUNCTION switch. f. FREQ-TIME switch. g. Reset button.

TABLE 5-8 TROUBLE-SHOOTING CHART (Continued)

MALFUNCTION	PROBABLE CAUSE OF FAILURE
8. Intermittent incorrect readout digit.	a. Decoder/Driver. b. Decade counter. c. + 5 V supply voltage. d. + 200 V supply voltage.
9. No reset to display.	a. Gates X-2. b. Buffers X-3. c. Diodes D-20 and D-21. d. Decade counters.
10. Double numbers and fuzzy display.	a. Decoder/Driver. b. Decade counter. c. Readout tube.

TABLE 5-9 TYPICAL POWER SUPPLY VOLTAGES

+ 3.6V CIRCUIT	VOLTAGE	RIPPLE
Q11 collector	+ 7.2 V	2 V P-P
Q11 base	+ 5.1 V	.2 V P-P
Q11 emitter	+ 4.5 V	.2 V P-P
Q12 collector	+ 7.2 V	2 V P-P
Q12 base	+ 4.5 V	.2 V P-P
Q12 emitter	+ 3.6 V	.2 V P-P
+ 5 V CIRCUIT		
D17 cathode	+ 5.1 V	.2 V P-P
+ 13 V CIRCUIT		
D18 cathode	+ 13 V	.2 V P-P
− 6 V CIRCUIT		
D19 anode	− 6.2 V	.1 V P-P
+ 200 V CIRCUIT		
D15 and D16 cathode junction	+ 210 V	5 V P-P
R41 and C23 junction	+ 200 V	.5 V P-P

NOTE:

The above voltages are typical values and will vary with component tolerances and line voltage.

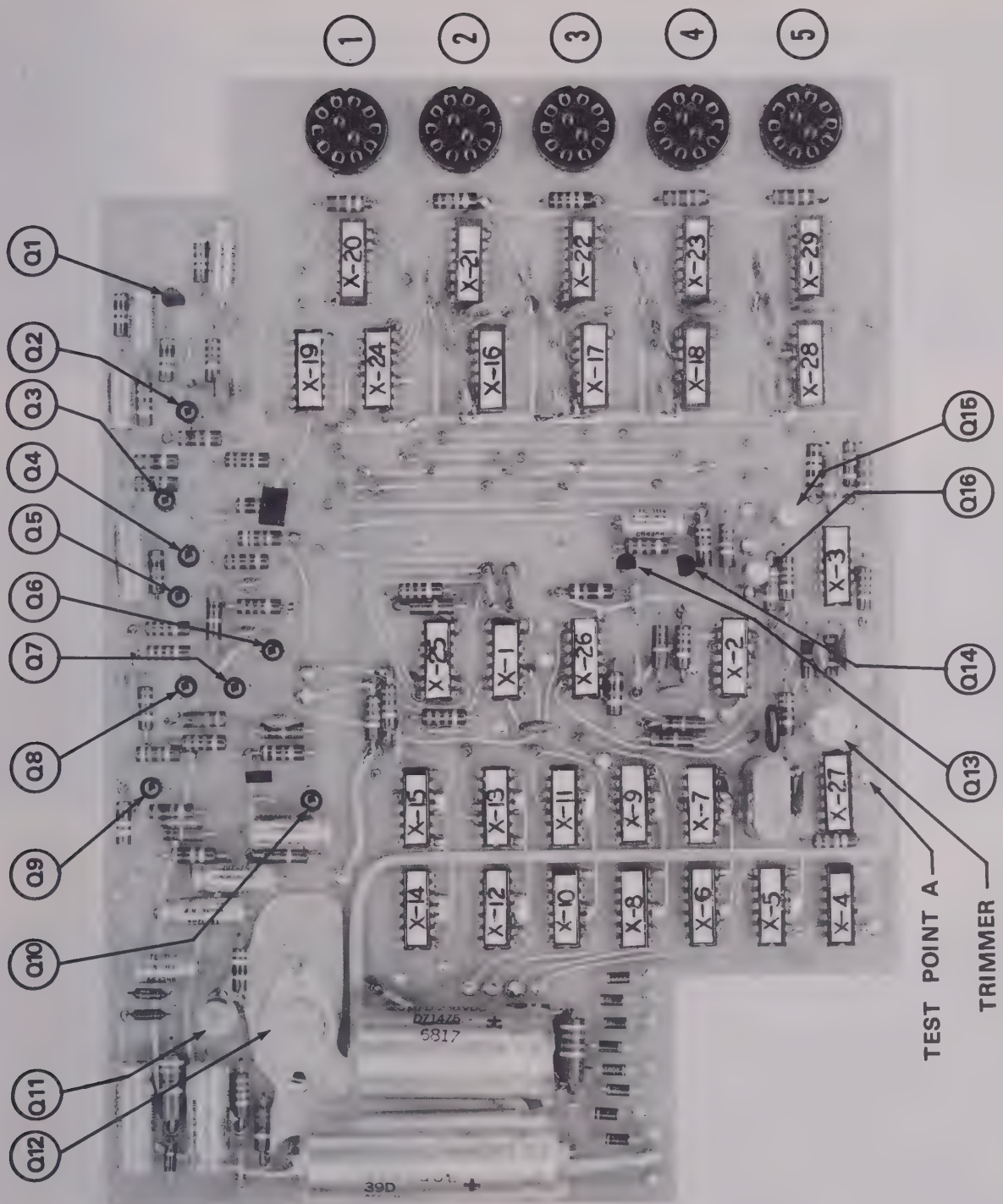


FIGURE 5-1 PRINTED CIRCUIT BOARD

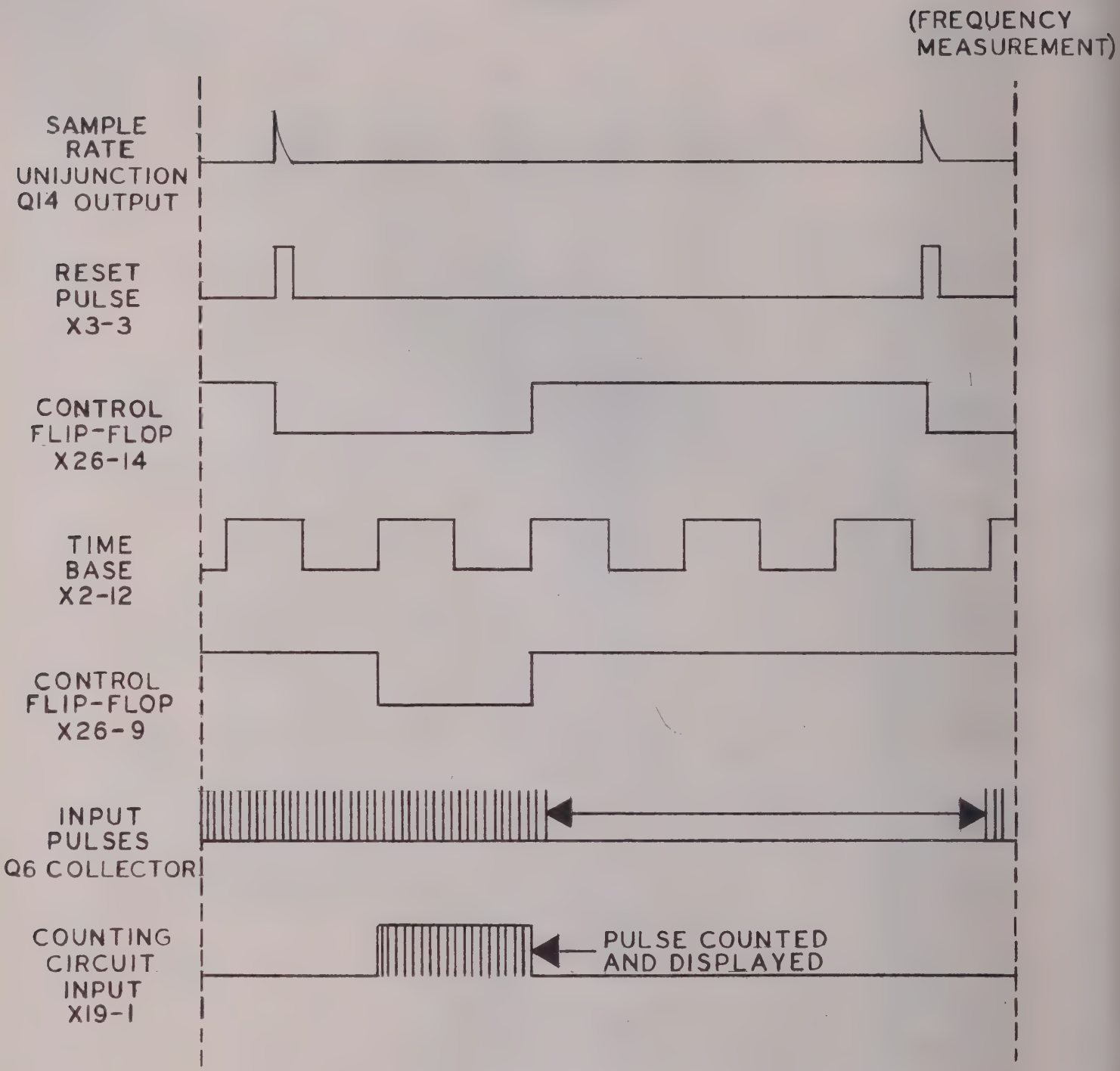
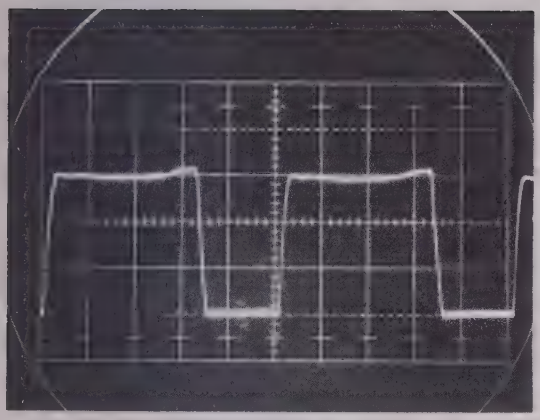
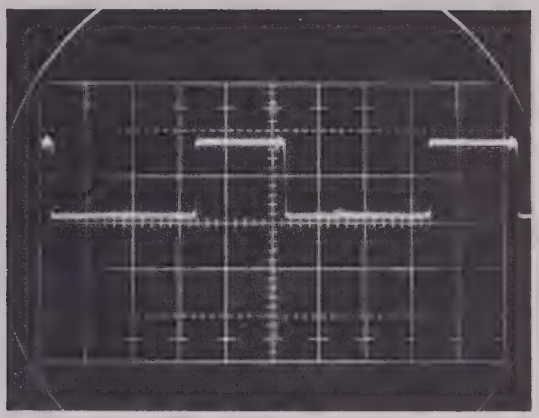


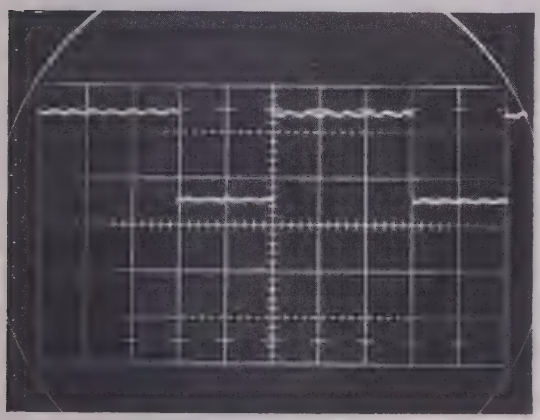
FIGURE 5-2 TIMING DIAGRAM (FREQUENCY MEASUREMENT)



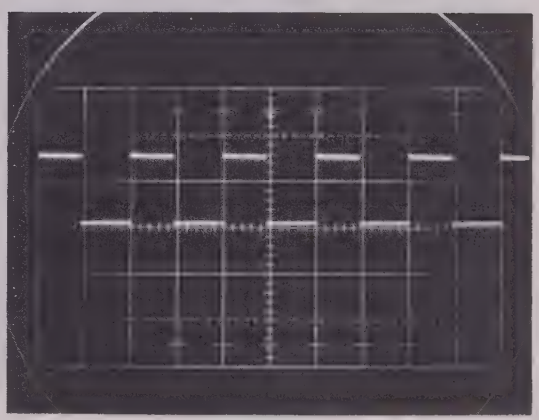
1. X27, Pin 10
2u Sec/cm, 1V/cm



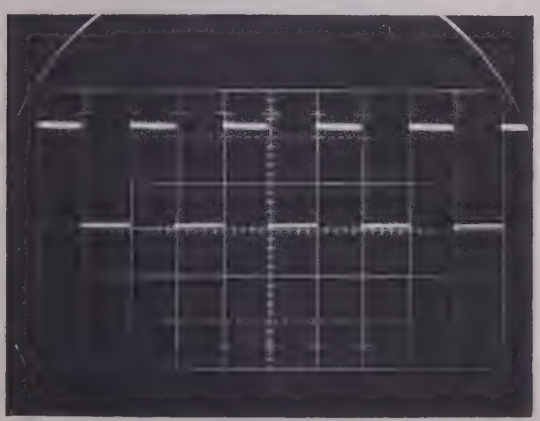
2. X27, Pin 5
2u Sec/cm, 1V/cm



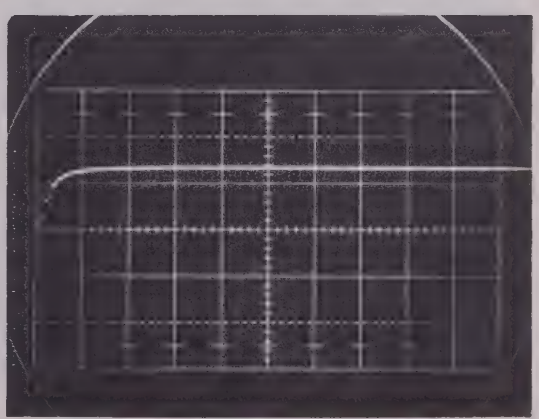
3. X11, Pin 9
20u Sec/cm, 0.5V/cm



4. Q6, Collector
50u Sec/cm, 1V/cm

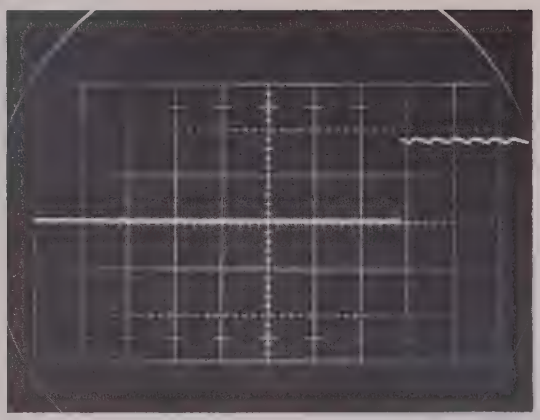


5. Q7, Collector
50u Sec/cm, 1V/cm

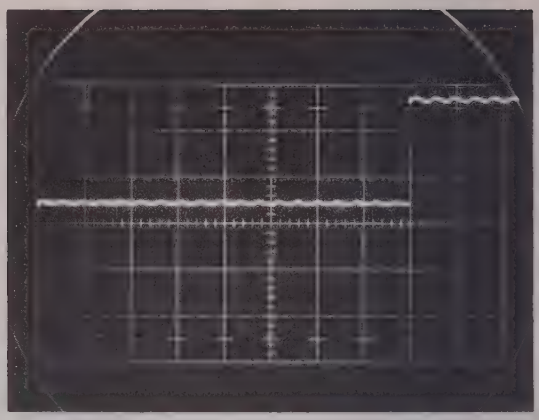


6. Q14, B1
1u Sec/cm, 1V/cm

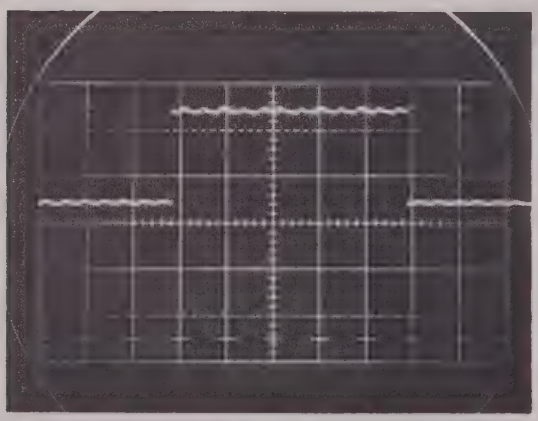
FIGURE 5-3 TYPICAL WAVEFORMS



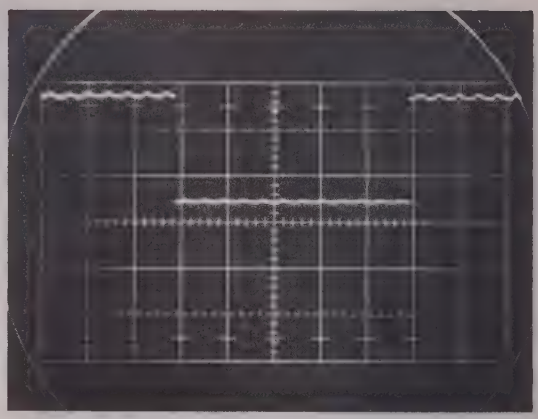
7. X27, Pin 6
20m Sec/cm, 2V/cm



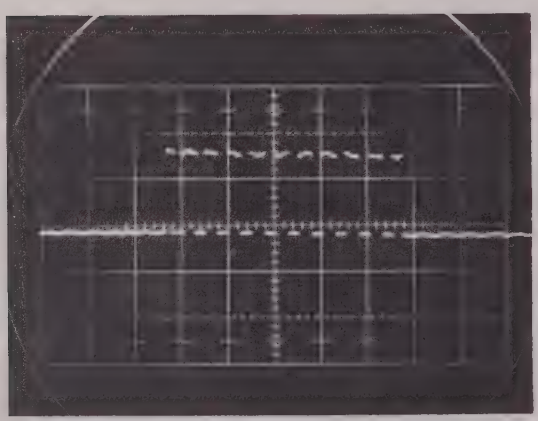
8. X26, Pin 14
20m Sec/cm, 0.5V/cm



9. X26, Pin 8
20m Sec/cm, 0.5V/cm



10. X1, Pin 2
20m Sec/cm, 0.5V/cm



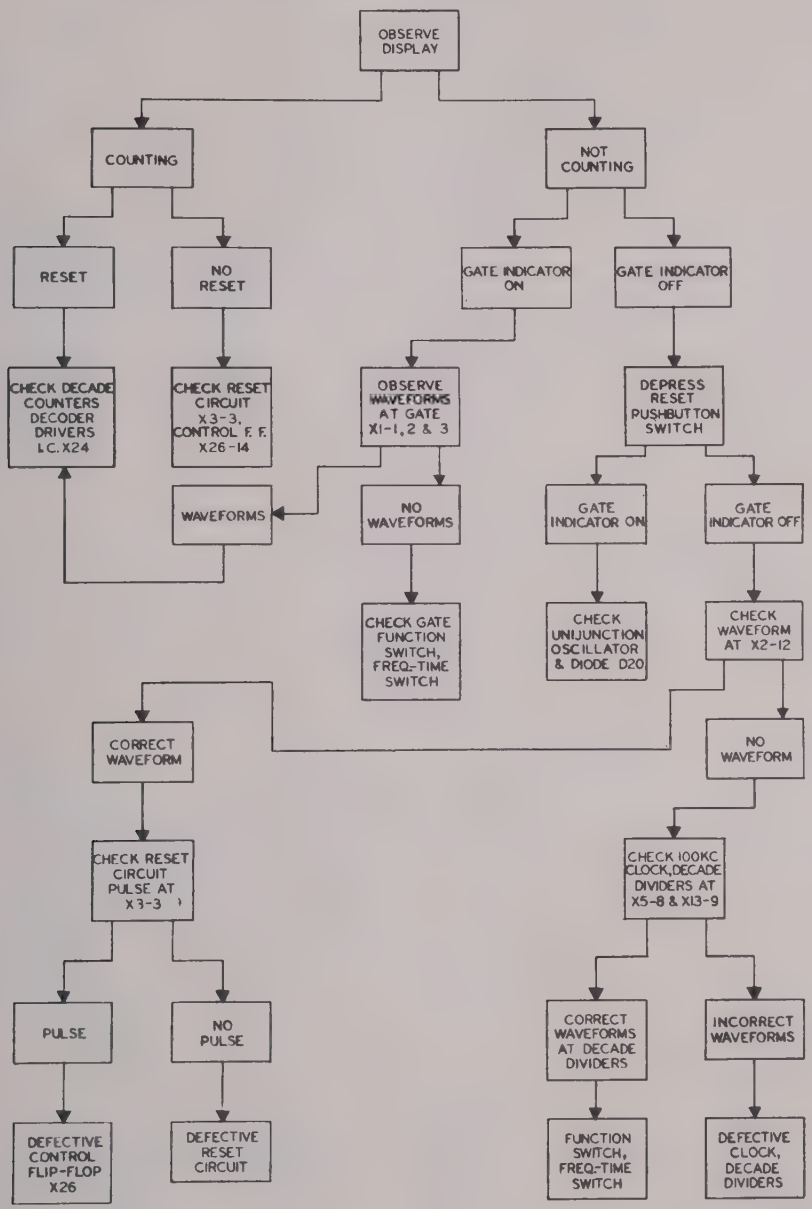
11. X1, Pin 3
20m Sec/cm, 1V/cm

NOTES:

1. **All waveforms are D.C. coupled.**
2. **Oscilloscope external trigger taken from X3, Pin 3.**
3. **Oscilloscope reference is the center line.**

FIGURE 5-3 TYPICAL WAVEFORMS (Continued)

1. Set instrument controls as follows:
   a. CLOCK switch (rear panel) to INT position.
   b. FUNCTION switch to SELF TEST position.
   c. FREQ-TIME switch to Hz sec position.
   d. DISPLAY TIME control slightly clockwise out of AC OFF.
2. Refer to Schematic Wiring Diagram for symbols.



3. Correct indication — MODEL 2724 — 0000 + overrange
   MODEL 2725 — 10000

FIGURE 5-4 LOCALIZING DIAGRAM (SELF TEST MODE)

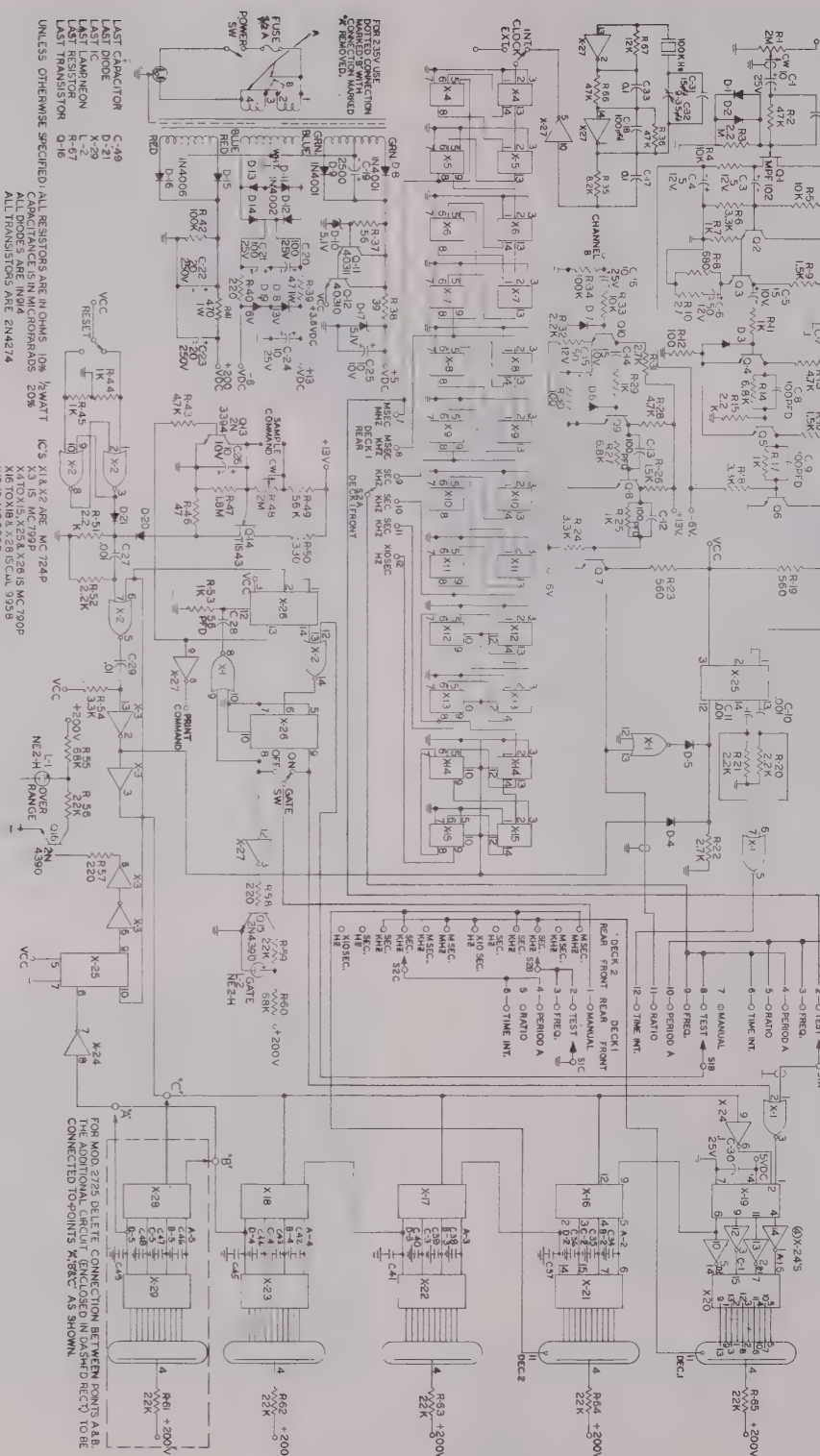


FIGURE 5-5 SCHEMATIC DIAGRAM

SECTION VI
REPLACEMENT PARTS

SYMBOL	PART NUMBER	DESCRIPTION
X1, X2	5-113186	Integrated Circuit, Quad 2 - Input Gate
X3	5-113187	Integrated Circuit Dual Buffer Inverter
X4, X5, X6, X7, X8, X9, X10, X11, X12, X13, X14, X15, X25, X26	5-113190	Integrated Circuit Dual J - K Flip-Flop
X16, X17, X18 (X28)	5-113188	Integrated Circuit RTL Decade Counter
X19	5-113185	Integrated Circuit DTL Decade Counter
X20, X21, X22, X23 (X29)	5-113189	Integrated Circuit Decoder-Driver
X24, X27	5-113191	Integrated Circuit Hex Inverter
Q1	5-113192	Transistor, FET, MPF102
Q2, Q3, Q4, Q5, Q6, Q7, Q8, Q9, Q10	5-113193	Transistor, NPN, 2N4274
Q11	5-113195	Transistor, NPN, 40311
Q12	5-113194	Transistor, NPN, 40310
Q13	5-112631	Transistor, NPN, MPS3394
Q14	5-112685	Transistor, Unijunction
Q15, Q16	5-112632	Transistor, NPN, 2N4390
D1, D2, D3, D4, D5, D6, D7, D20, D21	5-112004	Diode, Silicon, 1N914
D8, D9	5-113200	Diode, Rectifier, 1N4001
D10, D17	5-113197	Diode, Zener, 1N751A
D11, D12, D13, D14	5-113201	Diode, Rectifier, 1N4002
D15, D16	5-113199	Diode, Rectifier, 1N4006
D18	5-112726	Diode, Zener, 1N4743A
D19	5-112634	Diode, Zener, 1N753A
R10	1-116675	27 ±10% ½ watt
R38	5-113223	39 ±10% ½ watt
R46	1-113921	47 ±10% ½ watt
R39	1-119781	47 ±10% 1 watt
R37	1-115388	56 ±10% ½ watt
R12, R30	5-110835	100 ±10% ½ watt
R40, R57, R58	1-115612	220 ±10% ½ watt
R50	1-110645	330 ±10% ½ watt
R41	5-112310	470 ±10% 1 watt
R19, R23	1-116899	560 ±10% ½ watt
R8	1-118399	680 ±10% ½ watt
R7, R11, R17, R25, R29, R44, R45, R53	1-110644	1K ±10% ½ watt
R9, R16, R26	1-114681	1.5K ±10% ½ watt
R15, R20, R21, R32, R51, R52	1-113941	2.2K ±10% ½ watt
R22, R31	1-113942	2.7K ±10% ½ watt
R6, R18, R24, R54	1-114225	3.3K ±10% ½ watt
R13, R28, R43	1-114058	4.7K ±10% ½ watt
R14, R27	1-113048	6.8K ±10% ½ watt
R35	1-115464	8.2K ± 0% ½ watt
R4, R5, R33	1-111671	10K ± 10% ½ watt
R67	1-115655	12K ±10% ½ watt
R56, R59, R62, R63, R64, R65, (R61)	1-113439	22K ±10% ½ watt
R2, R36, R66	1-114881	47K ±10% ½ watt
R49	1-113947	56K ±10% ½ watt
R55, R58	1-114803	68K ±10% ½ watt
R34, R42	1-113949	100K ±10% ½ watt
R47	5-113278	1.8M ±10% ½ watt
R3	5-113203	2.2M ±10% ½ watt
R1	5-113323	Potentiometer, 2 meg-ohm
R48	5-113221	Potentiometer, 2 meg-ohm, with SPST switch
C31	1-115464	15 p f ±10%, Ceramic Disc
C28	5-110934	56 p f ±20%, Ceramic Disc
C8, C9, C12, C13, C34, C35, C36, C37, C38, C39, C40, C41, C42, C43, C44, C45, (C46), (C47), (C48), (C49)	5-113217	100 p f ±20%, Ceramic Disc
C2	5-113216	250 p f ±20%, Ceramic Disc
C10, C11, C27	1-119959	.001 u f ±20%, Ceramic Disc
C29	5-113215	.01 u f ±20%, Ceramic Disc
C7, C17, C30, C33	5-113214	.1 u f ±20%, Ceramic Disc
C3, C4	5-113213	5 u f 12 V, Electrolytic
C25, C26	5-113212	10 u f 10 V, Electrolytic
C1, C16, C24	5-113211	10 u f 25 V, Electrolytic
C5, C14	5-112800	15 u f ±20% 10 V, Tantalum
C22, C23 (in one package)	5-112808	20-20 u f 250 V, Dual Electrolytic
C6, C15	5-113209	50 u f 12 V, Electrolytic
C20, C21	5-113208	100 u f 25 V, Electrolytic
C19	5-113207	2500 u f 10 V, Electrolytic
C32	5-113206	Capacitor, Variable, 9 - 35 p f
	5-113328	Crystal 100 KHz
	10-861801	Counter P.C. Board Subassembly complete.
	5-113111	Transformer
	5-111622	Connector, BNC
	5-113222	Switch, Push Button
	5-113319	Switch, Slide
	5-113330	Switch, Toggle

Note: ( ) indicates items used on Model 2725.

SYMBOL	PART NUMBER	DESCRIPTION
	5-113314	Switch, Rotary
	5-112620	Tube, Readout, with Decimal
	5-113204	Tube, Readout
	5-111505	Lamp, Neon
	5-113331	Capsule, Neon, Red
	5-112273	Capsule, Neon, Clear
	5-113471	Knob, Round
	5-113470	Knob, Pointer
	5-112790	Cord, Power
	5-113312	Instruction Manual

NOTICE

The Models 2724 and 2725 are supplied in two different versions. One version is with X–19 being a Motorola MC838P (Simpson No. 5–113185) and the other version with X–19 being a Signetics N828OA on an adaptor board. (Simpson No. 10–862074).

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